Jet Propulsion Laboratory
California Institute of Technology

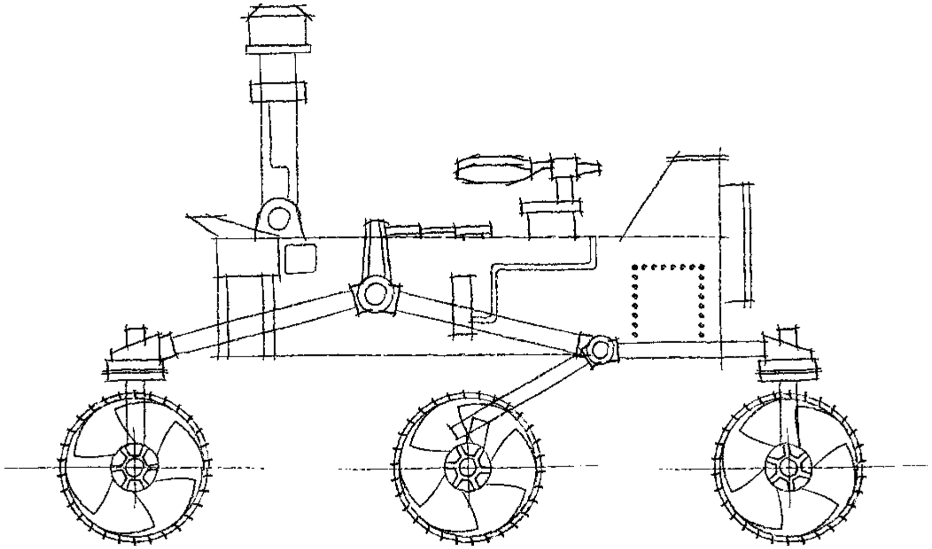
Mars 2020 Mission

Ken Farley

Project Scientist (Caltech)

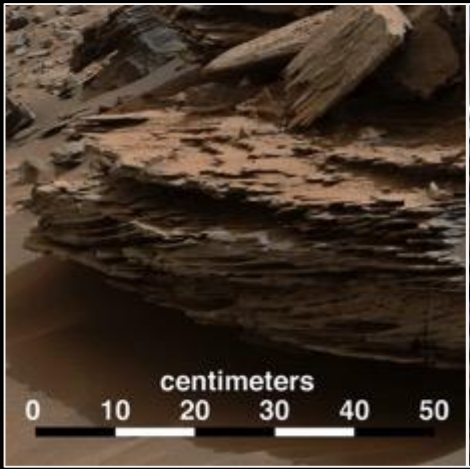
April 5, 2018

MEPAG Meeting



Mars 2020 Project

Mars 2020 Mission Objectives



GEOLOGIC EXPLORATION

- Explore an ancient environment on Mars
- Understand processes of formation and alteration

HABITABILITY AND BIOSIGNATURES

- Assess habitability of ancient environment
- Seek evidence of past life
- Select sampling locations with high biosignature preservation potential

PREPARE A RETURNABLE CACHE

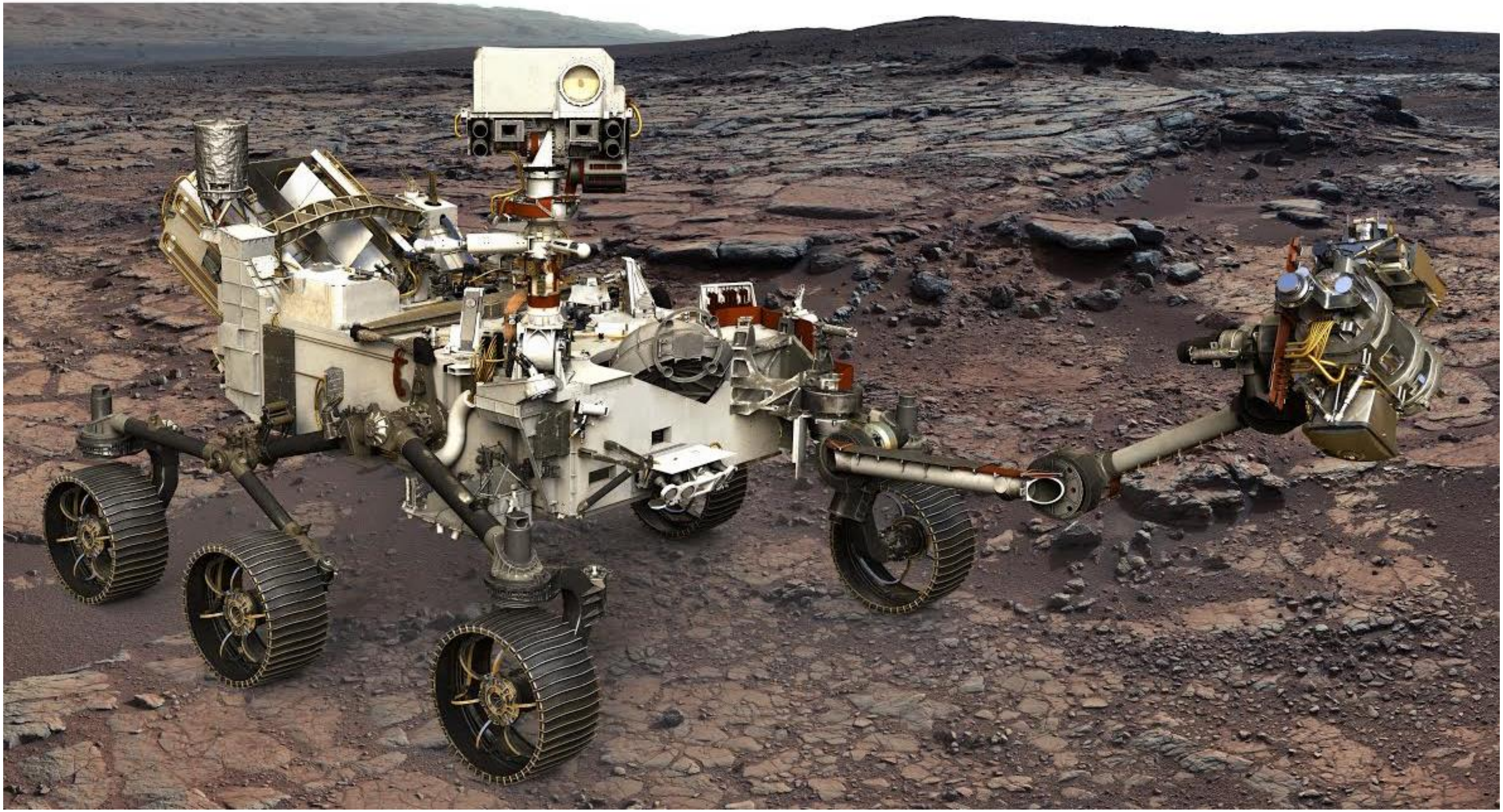
- Capability to collect ~40 samples and blanks, 20 in prime mission
- Include geologic diversity
- Deposit samples on the surface for possible return

PREPARE FOR HUMAN EXPLORATION

- Measure temperature, humidity, wind, and dust environment
- Demonstrate In Situ Resource Utilization by converting atmospheric CO_2 to O_2

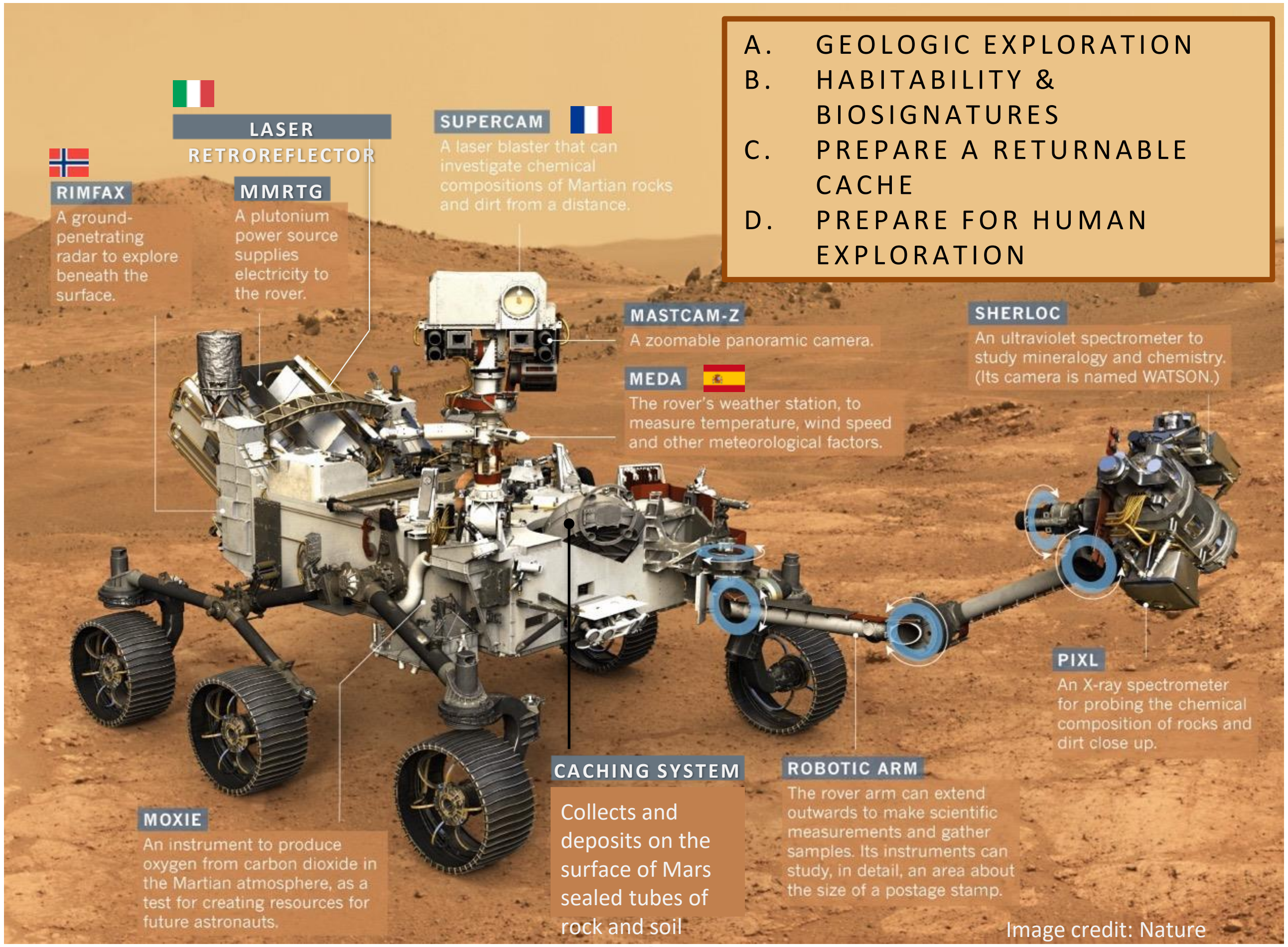
Mars 2020 Looks Like Curiosity

Similar, but different…



Mars 2020

- new science instruments
- new wheels
- new engineering cameras
- enhanced autonomy capabilities
- 5 hour ops timeline
- enhanced EDL cameras
-enhanced EDL capabilities
- helicopter (still being assessed)



Samples and Returnable Cache

The goal of Mars 2020 sample collection is to acquire a diverse suite of samples for the full range of investigations to which Martian samples are likely to be subjected upon Earth return

Specifically, the rover will be capable of:

1) Acquiring >= 37 samples total, and 20 samples in the prime mission (probably 1.5 Mars years)

   - consisting of rock + regolith + blanks

2) Rock samples: ~15 g cylinder (or cylindrical fragments)

3) Regolith: ~15 g (mixed - no preservation of stratigraphy)

4) Blanks: 5 witness tubes, and a single drillable blank

Samples

Sample Tube Math

Number of rock-regolith-blank tubes required by science: 37

Engineering margin (collection failure): 5

Total Number of sample tubes available on rover: 42

(rock and regolith tubes are identical; relative proportions will be determined by science team)

Number of samples that must be demonstrated to be acquirable in prime mission: 20

(this is a capability that drives efficiency and autonomy of operations)

Cache Returnability

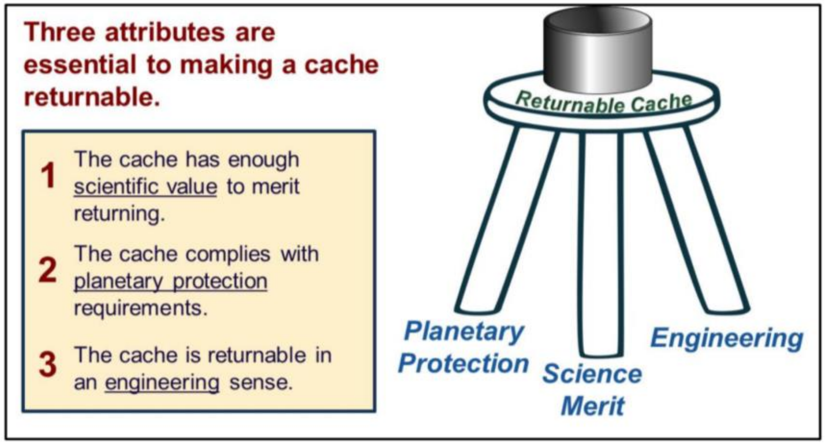


Figure 3-18. A returnable cache is one that has scientific value, complies with planetary protection requirements and meets proper engineering standards.

From the Mars 2020 SDT Report

How will science value be determined? How will we establish whether Mars 2020 is on track to meet the goal of cache returnability? Or that such a goal has been met?

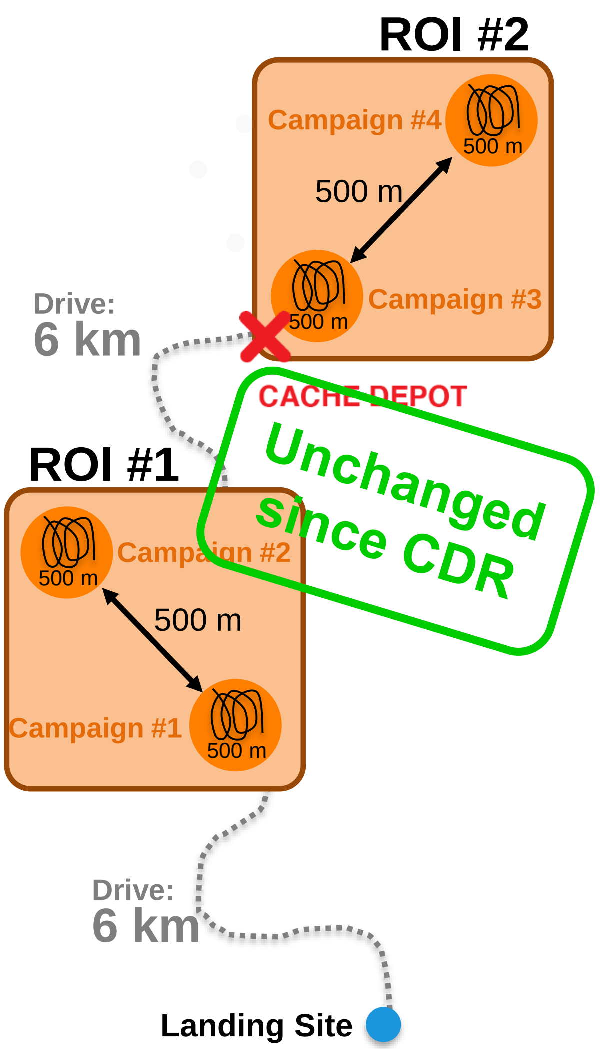
Numbers is one way, but perhaps not the best way…

Surface Operations
Baseline Reference Scenario

Jet Propulsion Laboratory
California Institute of Technology

The project system shall have the **capability to perform the following Baseline Reference Scenario** (BRS) surface mission within **1.25 Mars years (836 sols)**, which includes the following:

- Conduct the investigations required to meet science objectives A and B and meet technology objective D
- Explore 2 **Regions Of Interest** (ROI)
  - **6 km of long traverse** to achieve
  - **2 science campaigns** per ROI
  - **1.5 km of local traverse** to explore
  - Acquiring **9 cached samples** per ROI, consisting of 7 Mars rock / regolith samples and 2 witness blank samples
- Acquire 2 rock and/or regolith “waypoint” samples
- Single **Cache Depot** at a location near ROI #2



Samples

Jet Propulsion Laboratory
California Institute of Technology

Samples have tight requirements on sample integrity:

1. Cleanliness

- biologic: <1 viable terrestrial organism per tube, <10 total terrestrial organisms per tube [TBC]
    - on track to meet requirement with healthy margin
- organics: <10 ppb total organic carbon (TOC), < 1 ppb key marker compounds[1]
    - on track to meet requirements on rock cores, likely to be ~ 5x TOC on regolith
- elemental: limits on 21 geochemically important elements, based on Mars meteorite concentrations[2]
    - meeting requirements with healthy margin with exception of W, and possible challenges with Pb

2. Sample temperature not to exceed 60°C

- landing site dependent; but healthy margin at each

3. Limited fragmentation/fracture/powdering of rock samples

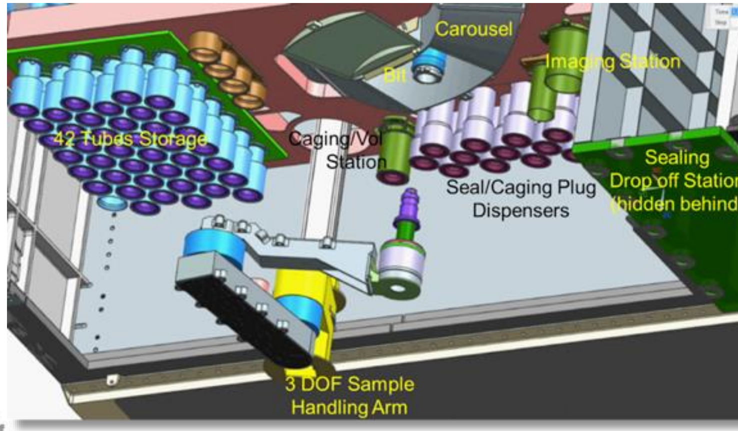
4. Hermetically sealed immediately after drilling and assessment

[1] see report of the Organic Contamination Panel; full citation in backup material

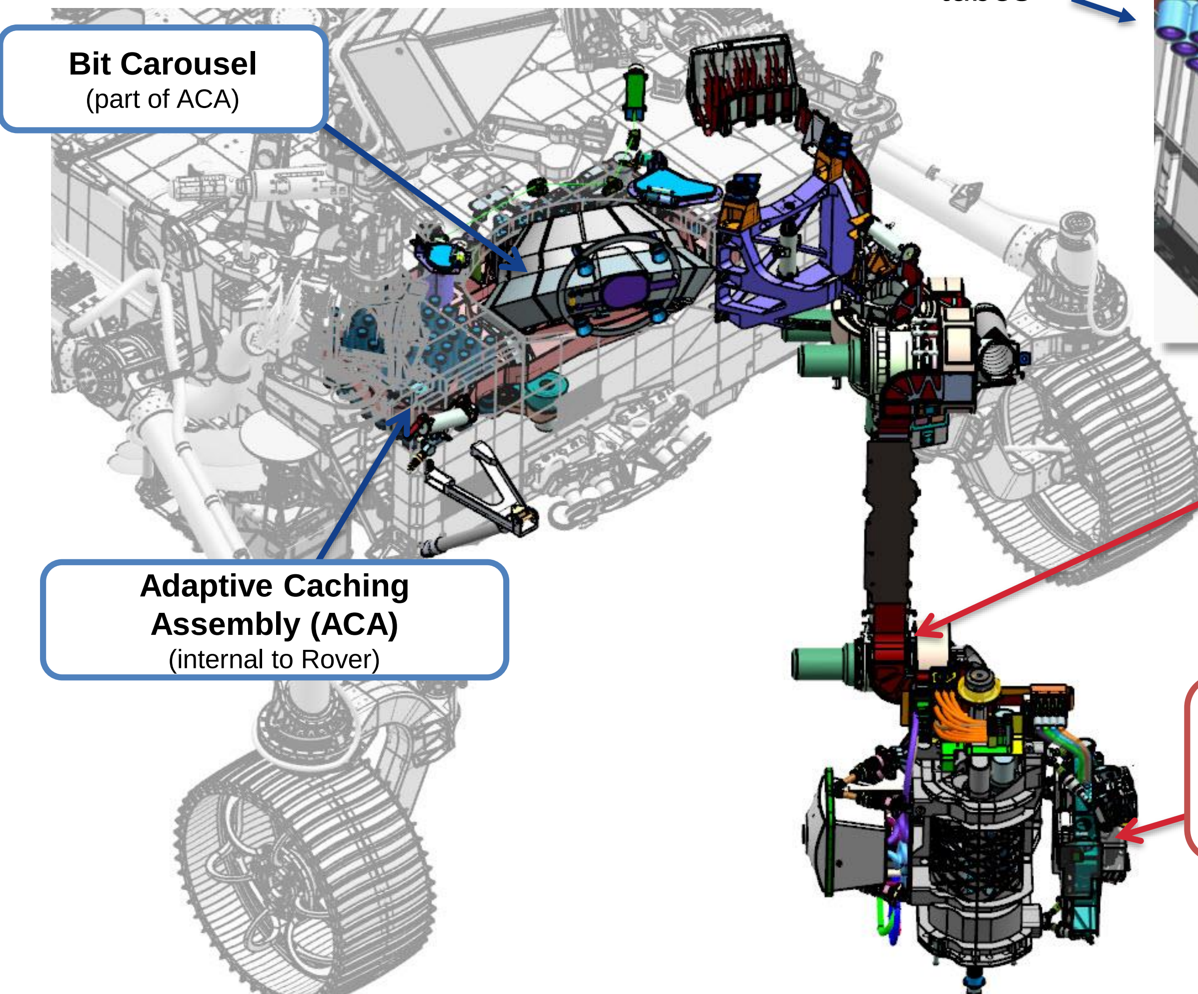
[2]Levels established from community assessment by D. Beaty et al., endorsed by mars 2020 Returned Sample Science Board

Sampling & Caching Subsystem (SCS)

~ 42 sample tubes



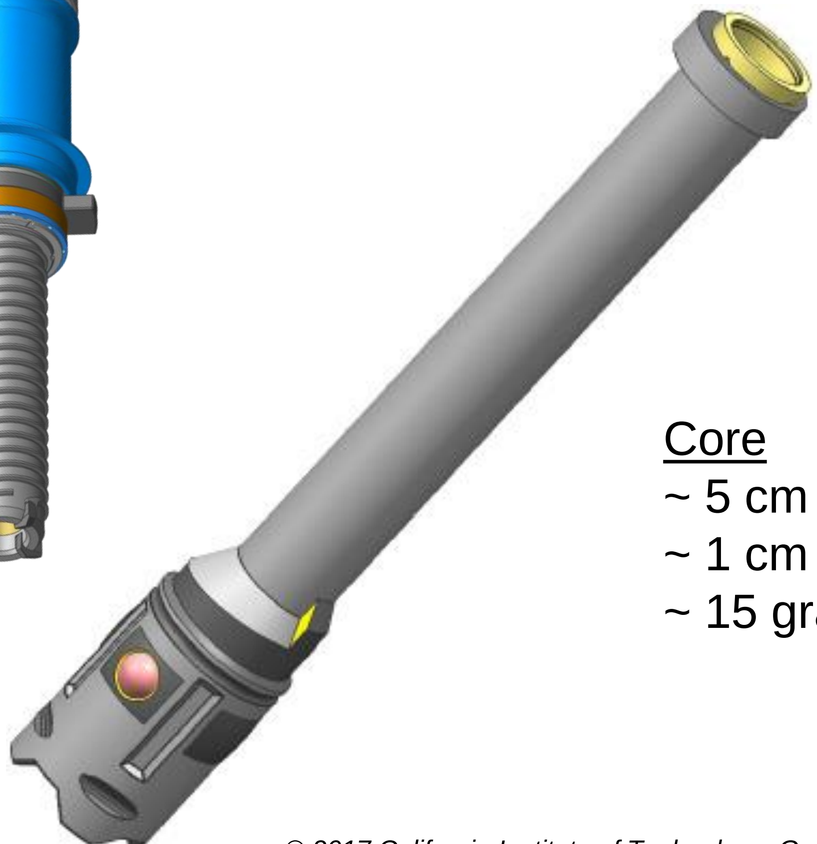
Caching Assembly



Coring and Sample Tube

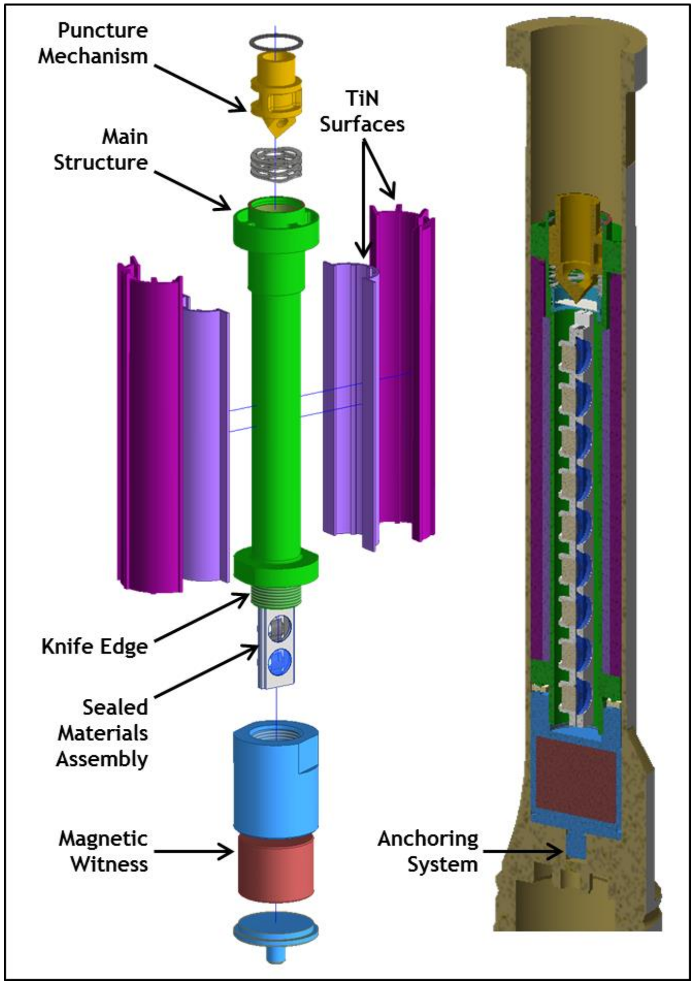
Coring Bit

Hermetically sealed sample tube



<u>Core</u>
~ 5 cm long x
~ 1 cm diameter
~ 15 grams

Witness Tubes

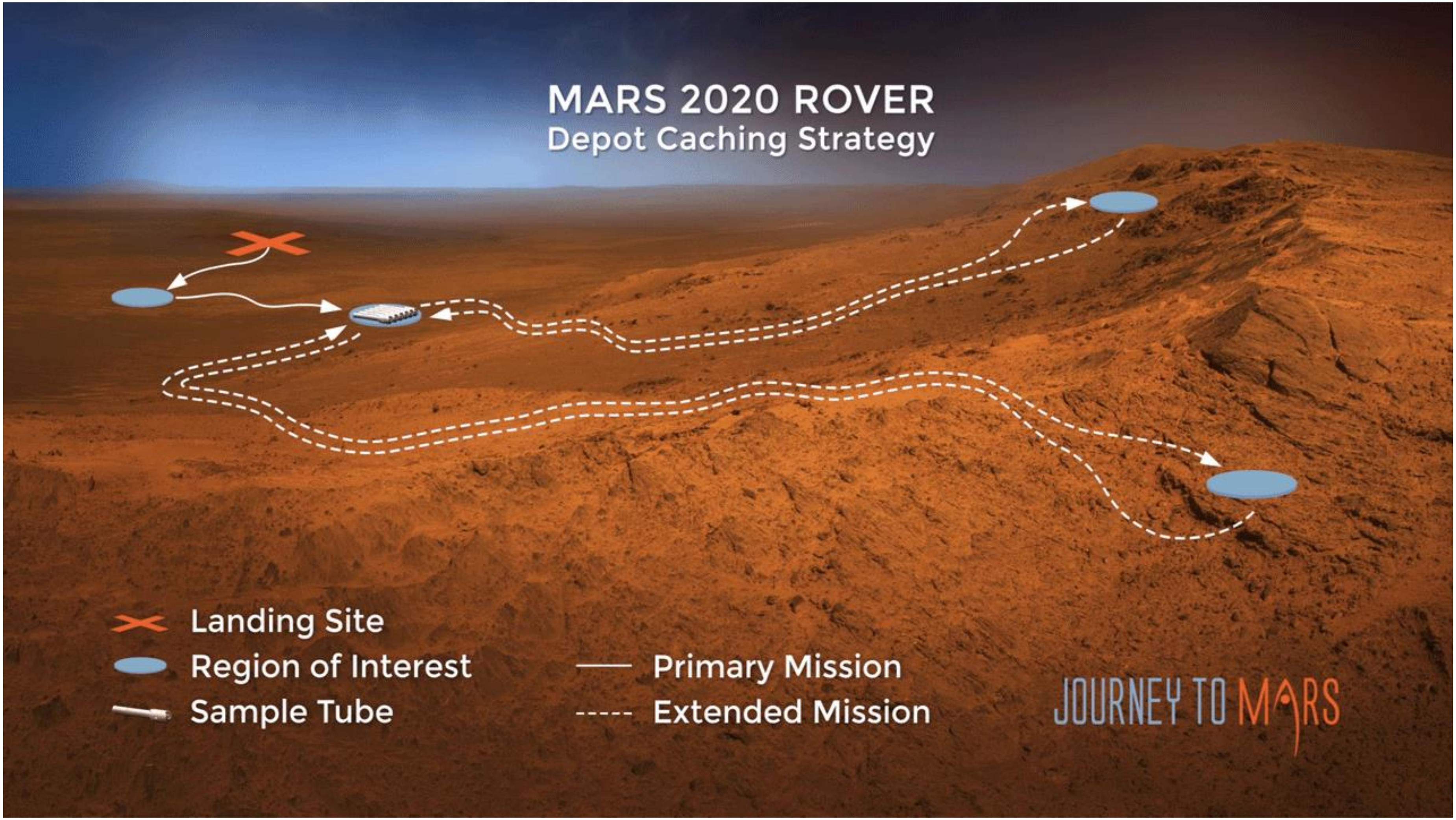


Specially built tube with various materials that acquire both particulate and vapor-phase contaminants. Exposed materials include aluminum, gold, titanium nitride.

Both meshes (high surface area, particle capture) and polished surfaces (appropriate for several important analytical methods) are included.

Some of the materials in each tube will be exposed from ATLO onward. Another set of materials in each tube is located within a sealed pouch that will be punctured just before blank acquisition.

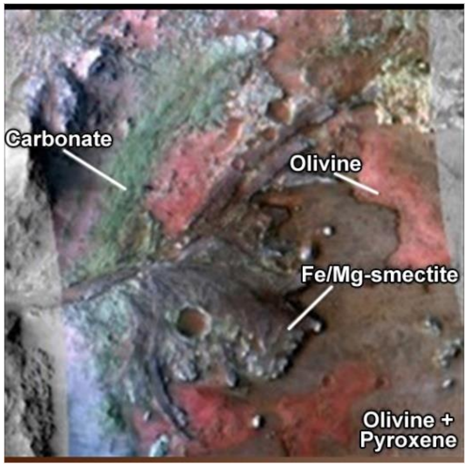
Depot Caching

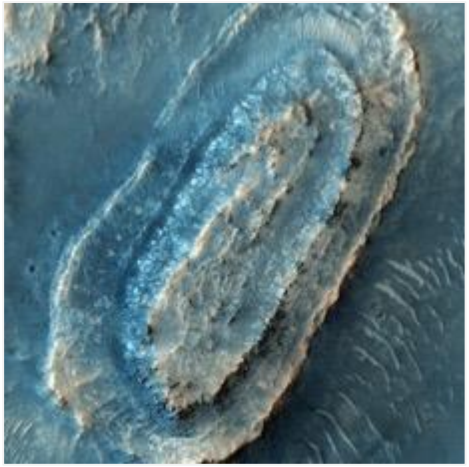


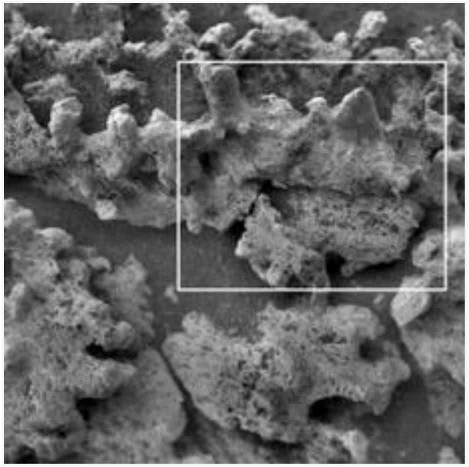
Landing Site Selection

Jet Propulsion Laboratory
California Institute of Technology

Mars 2020 Project







JEZERO

- Deltaic/lacustrine deposition with possible igneous unit and hydrous alteration
- Minerologic diversity including clays and carbonates
- Shallow water carbonates?

NE SYRTIS

- Extremely ancient igneous, hydrothermal, and sedimentary environments
- High mineralogic diversity with phyllosilicates, sulfates, carbonates, olivine
- Possible serpentinization and subsurface habitability

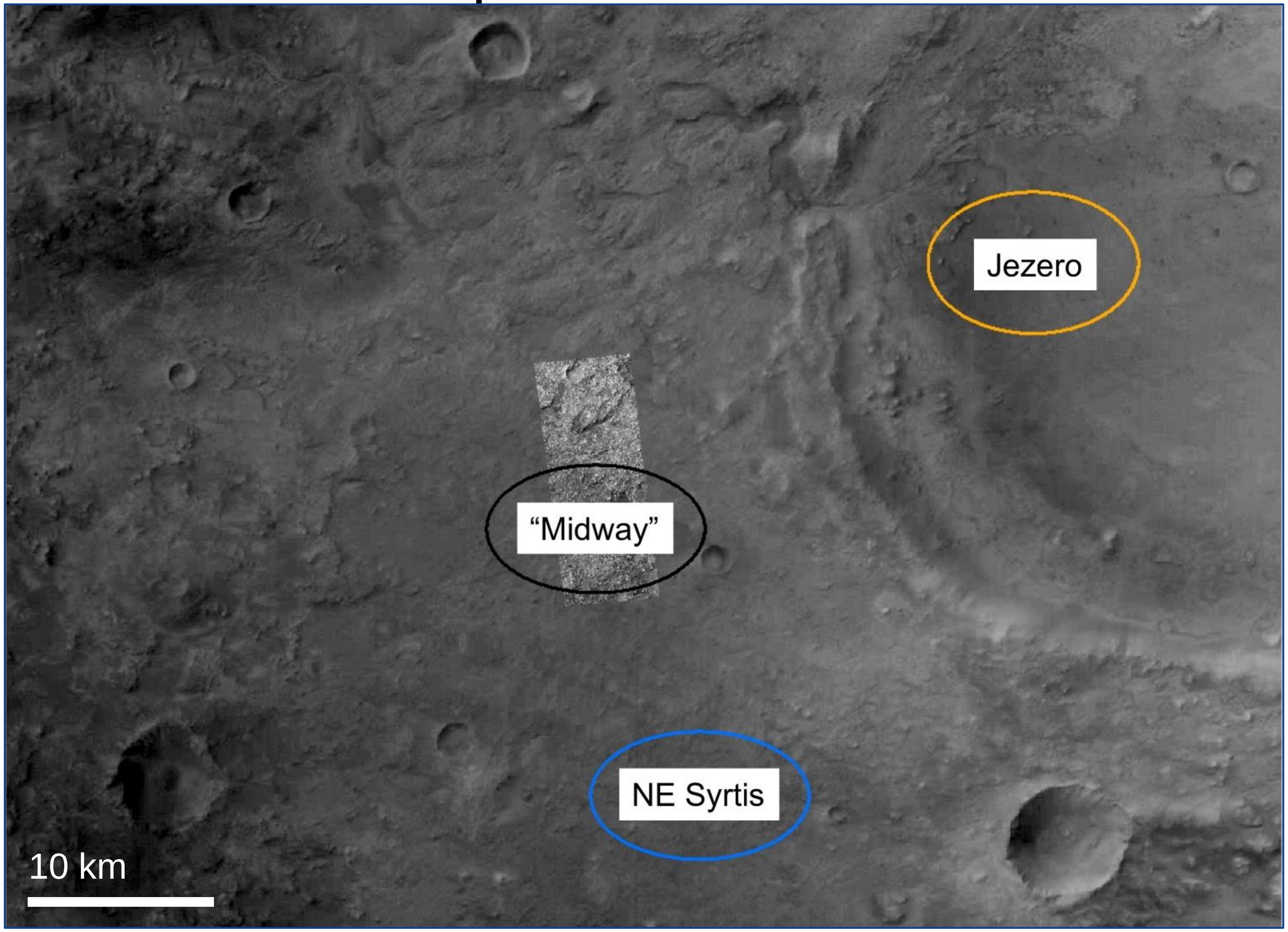
COLUMBIA HILLS

- Carbonate, sulfate, and silica-rich outcrops of possible hydrothermal origin. Hesperian volcanics.
- Potential biosignatures identified
- Previously explored by MER

Final Community Workshop: Oct '18, Open to all Interested Scientists

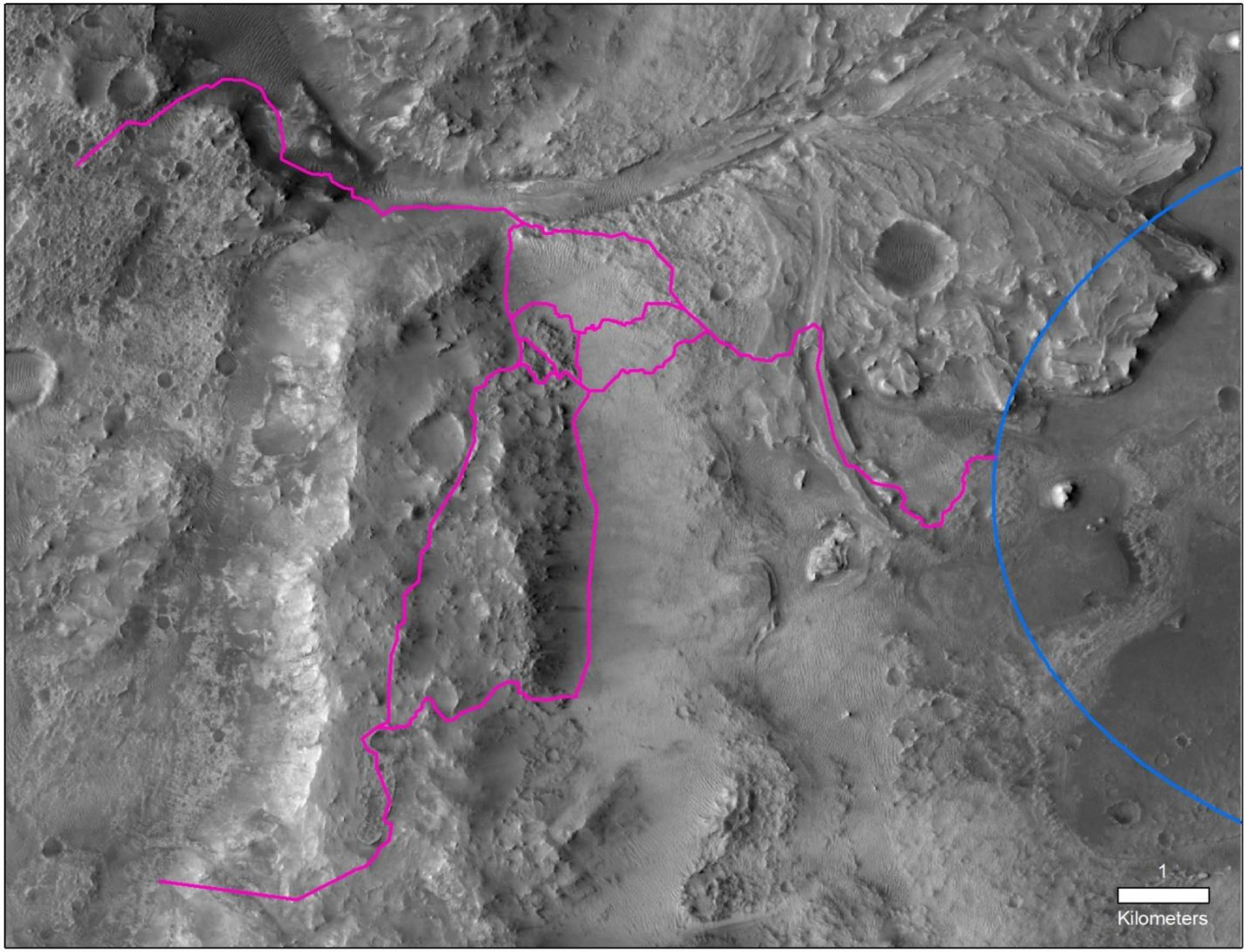
“Midway”

- Safe landing ellipse featuring NE Syrtis-type terrain located as close as possible to Jezero Crater?



Jezero to Midway traverse

Jet Propulsion Laboratory
California Institute of Technology



Current Status

- Just Completed System Integration Review
- Key Decision Point D in April 2018
- Assembly, Test, and Launch Operations have begun
    - final fine-tuning and start of implementation of Contamination Knowledge Plan, in consultation with JSC Curation team. Contamination knowledge artifacts will be curated at JSC.

Milestones to Launch

Jet Propulsion Laboratory
California Institute of Technology

Date	Status/Description
Jan 25, 2018	Assembly, Test, and Launch Operations Readiness Review
Feb 27-28, 2018	System Integration Review (Formal approval to proceed into system integration & test)
Apr 10, 2018	Planned first power on of Mars 2020 flight hardware in the JPL Spacecraft Assembly Facility
Feb, 2018	Begin Vehicle Stack to Cruise Configuration
Apr, 2018	Cruise Configuration Thermal Vacuum Test
May, 2018	Vehicle de-stack
Sep/Oct, 2018	Surface Thermal Test
Dec, 2019	Pre-Ship Review prior to vehicle shipment to KSC
Feb, 2020	Ship vehicle to KSC
May/June, 2020	Stack vehicle to launch configuration
Jun/Jul, 2020	Launch vehicle fairing encapsulation and transport to launch pad
Jul 17, 2020	Launch period opens

Mission Overview

LAUNCH

- Atlas V 541 vehicle
- Launch Readiness Date: July 2020
- Launch window: July/August 2020

CRUISE/APPROACH

- ~7 month cruise
- Arrive Feb 2021

ENTRY, DESCENT & LANDING

- MSL EDL system (+ Range Trigger and Terrain Relative Navigation): guided entry and powered descent/Sky Crane
- 16 x 14 km landing ellipse (range trigger baselined)
- Access to landing sites ±30° latitude, ≤ -0.5 km elevation
- Curiosity-class Rover

SURFACE MISSION

- 20 km traverse distance capability
- Enhanced surface productivity
- Qualified to 1.5 Martian year lifetime
- Seeking signs of past life
- Returnable cache of samples
- Prepare for human exploration of Mars

BACKUP

Mars 2020 Mission Objectives

- **Conduct Rigorous *In Situ* Science**
  - **Geologic Context and History** Characterize the processes that formed and modified the geologic record within a field exploration area on Mars selected for evidence of an astrobiologically-relevant ancient environment and geologic diversity
  - **In Situ Astrobiology** Perform the following astrobiologically relevant investigations on the geologic materials at the landing site:
    1. Determine the habitability of an ancient environment.
    2. For ancient environments interpreted to have been habitable, search for materials with high biosignature preservation potential.
    3. Search for potential evidence of past life using the observations regarding habitability and preservation as a guide.
- **Enable the Future: Sample Return**
  - Assemble rigorously documented and returnable cached samples for possible future return to Earth.
    1. Obtain samples that are scientifically selected, for which the field context is documented, that contain the most promising samples identified in Objective B and that represent the geologic diversity of the field site.
    2. Ensure compliance with future needs in the areas of planetary protection and engineering so that the cached samples could be returned in the future if NASA chooses to do so.

Mars 2020 Mission Objectives

- **Enable the Future: Human Exploration**
  - Contribute to the preparation for human exploration of Mars by making significant progress towards filling at least one major Strategic Knowledge Gap (SKG). The highest priority SKG measurements that are synergistic with Mars 2020 science objectives and compatible with the mission concept are:
    1. Demonstration of In-Situ Resource Utilization (ISRU) technologies to enable propellant and consumable oxygen production from the Martian atmosphere for future exploration missions.
    2. Characterization of atmospheric dust size and morphology to understands its effects on the operation of surface systems and human health.
    3. Surface weather measurements to validate global atmospheric models.
    4. A set of engineering sensors embedded in the Mars 2020 heat shield and backshell to gather data on the aerothermal conditions, thermal protection system, and aerodynamic performance characteristics of the Mars 2020 entry vehicle during its entry and descent to the Mars surface.

Organic Limits

- **Planning Considerations Related to the Organic Contamination of Martian Samples and Implications for the Mars 2020 Rover**

2014 Organic Contamination Panel, Summons R.E., Sessions A.L., (co-chairs), Allwood A.C., Barton H.A., Beaty D.W., Blakkolb B., Canham J., Clark B.C., Dworkin J.P., Lin Y., Mathies R., Milkovich S.M., and Steele A.. Astrobiology. December 2014, 14(12): 969-1027. https://doi.org/10.1089/ast.2014.1244